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ABSTRACT

Several studies of mathematics education have singled out the early and rigid ability grouping as one of the principal reasons for mathematics underachievement in the United States. Public schools in the United States engage in extensive sorting of students into sharply differentiated curricula by the end of sixth or seventh grade. This study examines the ways in which students' assignment to ability groups in middle and secondary school mathematics are influenced by the organizational features and placement policies of the schools themselves. Specifically, this research examines the fast track in mathematics which includes only 16 to 17 percent of U.S. students and is critical for qualification for college mathematics and physical science programs. The views of college admissions officers, variations by district in accelerated mathematics courses, explanations for variations in enrollment patterns, organizational factors influencing group assignment, and several case studies are discussed. Findings indicate that there are substantial variations in ability grouping that lead to inequities and arbitrary elements in student placement and that the range of abilities found in higher level tracks among different school systems can be explained by individual characteristics, and attitudes among school administrators. Implications for women and minorities are suggested. A list of 67 references is included. (CW)

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Getting on the Fast Track in Mathematics: School Organizational Influences on Math Track Assignment

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Several recent studies of mathematics education have singled out the early and rigid ability grouping as one of the principal reasons for mathematics underachievement in the U.S. (Kifer, 1986, 1989; McKnight, 1987; Usiskin, 1987). Public schools in the U.S. engage in extensive sorting of students into sharply differentiated curricula by the end of sixth or seventh grade, and nearly all of the students remain in that assigned track or move downward to a lower level of difficulty during the high school years (Jones et al., 1972; Evans and Galloway, 1973; Rosenbaum, 1976; Rosenbaum and Velez, 1978; Massachusetts Department of Education, 1986; Garet and DeLany, 1987). The alarmingly small pool of American-born students entering college prepared to pursue quantitatively-oriented programs can in part be explained by middle school tracking practices which effectively choke off the supply of students pursuing an accelerated mathematics curriculum (Kifer, 1986, 1989).

This study examines the ways in which students' assignment to ability groups in middle and secondary school mathematics are influenced by the organizational features and placement policies of schools themselves. In particular, this research looks at the placement of students in the "fast track" in mathematics, i.e. the sequence of courses that includes algebra in the eighth grade leading to calculus in the twelfth grade. Only 16 to 17 percent of U.S. students are placed in this accelerated sequence in eighth grade (Becker, 1990), and fewer still, about 5 to 6 percent, persist into calculus (Peng, 1984), substantially fewer than is the case in other industrialized countries where calculus is the standard twelfth grade mathematics course (Kifer, 1986, 1989; McKnight, 1987; Dossey et al., 1988). As Kifer notes, the sorting of students in U.S. schools is so extensive and exclusionary that by grade eight the proportion of students taking algebra is about the same as those taking advanced math in grade twelve in other countries.

Further, Kifer's analysis of data from the Second International Mathematics Study shows that there is extensive misclassification of students in the assignment process as well (Kifer, 1987, 1989). He attributes the fact that many high-scoring students are not placed in eighth grade algebra both to the impact of student background characteristics--higher social class students, whites, and females are overrepresented--and to variations in placement criteria that exist among school districts. This research builds upon Kifer's findings and offers a detailed look at the effects of school placement policies on student assignment to accelerated mathematics in 26 school districts.

Assignment to the accelerated track in mathematics can have profound ramifications for a student's secondary school experience. A large-scale survey of student transcripts in Massachusetts revealed that those who were placed in algebra in the eighth grade as well as a foreign language were much more likely than other students to pursue an academically rigorous curriculum in high school (Masachusetts State Department of Education,

1986). For example, 62 per cent of these students went on to take physics compared to 30 percent of other students, and 53 per cent took calculus in high school compared with only 13 per cent of those who were not assigned to algebra and a language in the eighth grade. Placement in this curricular sequence was highly correlated with placement in honors English and history courses during the high school years. Students in this accelerated sequence in the eighth grade also registered substantially higher SAT scores (80 points in verbal score and 100 points in the math score) as juniors and seniors than their peers who were not placed in this more academically demanding curriculum. A further advantage of placement in the advanced track leading to calculus is that students in it are in mathematics classes with other highly motivated students, an important benefit in contemporary American school cultures where the majority of students are not seriously engaged in learning (Powell et al., 1985; Sedlak et al., 1986).

While mathematics educators are divided over the importance of learning calculus in high school (see Douglas, 1986; Steen, 1987), secondary students who take this course gain several significant advantages from doing so. First, many educators, especially high school teachers themselves, believe that secondary calculus classes are better taught than college calculus classes. The high school classes are usually smaller and more personal, the teachers assigned to them are often the best in the department, the class meets more frequently than college classes, material is explained in more detail, homework is more likely to be graded, and the teacher is more available to students for extra help. College classes, especially those in large universities, tend to be larger, less student-centered, and often taught by foreign-born graduate students or professors whose English is more limited. While teaching calculus is viewed as an attractive opportunity for high school teachers, college professors shy away from teaching such an introductory-level course (Cipra, 1987; Dodge, 1987; Fulton, 1987; Kolata, 1987; and Steen, 1987).

A second advantage is that students who take calculus in high school are more likely to pass the introductory calculus course in college, and a significant difference persists even when initial mathematics aptitude as measured by the SAT is taken into account (Burton, 1989). Those who score high (a 4 or 5) on the AP exam (about six percent of all those taking calculus in high school) are especially likely to be successful in college calculus courses (Cipra, 1987; Douglas, 1987; and Small, 1987). This is an important advantage since the flunk-out and withdrawal rates from college calculus courses are extremely high, together averaging 35 percent, and ranging as high as 50 to 60 percent in large schools. Calculus is the course that "filters" students out of mathematics and related disciplines, thus selecting them out from the more than half of college majors that require calculus as a prerequisite course (Douglas, 1987, 1988; Kolata, 1987; Steen, 1987; National Research Council, 1989).

Third, students enrolled in high school calculus gain "symbolic capital" as well (Kifer, 1986). The calculus course on the transcript is a

signal to teachers, guidance counsellors and college admissions offiers that the student is a member of the academic elite just as courses i Greek and Latin in the past (and perhaps non-Western languages today) confrred prestige and an aura of high ability. Rosenbaum (1986) has describe the importance of such signaling as students progress in tournament-likefashion in their educational careers. He argues, as Cicourel and Kitsuse (163) did earlier, that ability is to some degree a social construct, "a socil status conferred to individuals by their peers and supervisors."(p. 57) Students who continue to be selected into ever-more advanced mathemaics courses during high school are much more likely than others to be labled as high ability students regardless of their actual proficiency. As on mathematics educator has put it, "a calculus course on the transcript is the sign of an educated person" (Tucker, 1987, p. 15).

Although recent research on the effects of tracking has documentd the importance of coursetaking in advanced mathematics in boosting mathemtics achievement (Gamoran, 1987; Dossey et al., 1988), researchers have faled to show specific achievement gains accruing to students who pursue the accelerated sequence of courses leading to calculus in the twelfth grde. This is due in part to the limitations of the large-scale data sets available to researchers such as High School and Beyond, the National Assessment for Educational Progress, and the Scholastic Aptitude Test These studies do not test students for their knowledge of calculus. bsent such data, it is reasonable to conjecture that students who take calclus know more calculus than students who have never been exposed to it! he presence of such data would surely provide a useful correction to the underestimation of track effects which has most likely occurred in th analysis of national survey data. Those who have used qualitative reearch methods have reported more substantial tracking effects than those wh have relied on quantitative survey research but they too have not isolatedthe effects of taking the accelerated mathematics program through calculu (see Gamoran and Berends, 1987, for a review of the tracking effects literture).

The present research, following Kifer (1987, 1989), builds on th assumption that placement in an accelerated mathematics curriculum sequence confers significant advantages to those assigned there. The paper wil show that this probability varies significantly and arbitrarily from schoo district to school district. Researchers in the field of tracking hae increasingly turned their attention to the effects of school-level organizational characteristics on student coursetaking patterns. Thee is growing recognition that while students' background characteristics hve a substantial influence on course assignment and track placement (see Gaoran and Mare, 1989, for a summary), school-based practices and policies hve a significant independent effect on these placements as well (Sorensen, 970; Schafer and Olexa, 1971; Rosenbaum, 1976; Eder, 1979; Hallinan and Sorenson, 1983; Oakes, 1985; Garet, Agnew and DeLany, 1987; Gamoran, 87; Jones, Vanfossen and Spade, 1987; Garet and DeLany, 1988; Lee and Bryk 1988, 1989). Sorensen (1987) has argued that students' opportunities o learn are more closely tied to local district and school-level policie than

large-scale national surveys have led us to believe. This paper, building on this line of research, looks closely at variations among schools in their policies and procedures governing students' opportunity to be assigned to the accelerated track in mathematics and examines the causes and consequences of these variations.

Research Methods

In order to ascertain school policies governing ability group and track placement in mathematics, I interviewed 52 school administrators, most of them mathematics chairs or coordinators, in the 26 public school districts that lie within or border on the area bounded by the two major expressways around Boston (Routes 93 and Route 128). The demographic profiles of the communities varied widely from poor districts to very wealthy suburbs. The chairs in these districts were in charge of high school departments of mathematics but often exercised supervisory responsibility over the junior highs or middle schools as well. Some districts had mathematics coordinators who oversaw the mathematics curriculum and grouping practices for the district from kindergarten through twelfth grade.

The semistructured interviews lasted approximately 45 minutes and were conducted in the spring of 1989. Forty-one of the interviews were conducted in person and the other 13 were conducted over the telephone. In all but one of the districts, at least one interview per district was conducted in person. In school districts where a mathematics coordinator could knowledgeably answer questions about the whole system, only one person was interviewed. In those where there was more than one comprehensive high school, where there was no system-wide coordinator or chair of mathematics, or where a coordinator lacked certain pieces of information, interviews were conducted with other administrators as well.

Course catalogs and other written policy documents of the systems were evaluated. Recent comparative data by district and by school on parental education levels and achievement test scores (a uniform state math assessment test given at three grade levels in all districts in 1988 and 1986) were made available by the Massachusetts State Department of Education. That agency also provided updated information on system-wide dropout rates and rates of private school attendance.

In addition, I conducted more extensive case studies in two of the 26 public school districts. The two suburban middle to upper-middle class communities, adjacent to one another geographically, were similar in demographic characteristics.(1) In those two communities, I interviewed teachers, parents, and administrators, focusing especially on the dynamics of the course placement process in mathematics as children make the critical transition between elementary school and middle and junior high school. In the first community, Community A, where students move into a two year junior high from K-6 elementary schools, the following groups were interviewed:

all of the 11 sixth grade mathematics teachers in the 10 elementary schools feeding into the junior high; the five seventh grade mathematics teachers plus five administrators of the mathematics program in the school system; and 45 parents (43 mothers and two single-parent fathers) of seventh graders randomly selected from student class lists. These structured interviews were conducted in the fall of 1988.

In Community B, where students go into a middle school (grades 6-8) from the town's five elementary schools, I interviewed nine of the fifth grade mathematics teachers (two at four of the elementary schools and one at a fifth school), two of the three guidance counsellors at the middle school, three school administrators, all of the nine mathematics teachers in the three grades at the middle school, and a randomly selected sample of 41 mothers of children who were just finishing the sixth grade. The interviews in Community B took place from May to July of 1989. The results from the parent interviews from both communities are reported elsewhere (Useem, 1990a,b).

A sample of 27 college admissions officers were interviewed on the telephone as well during the summer of 1988. Twenty-two of the 27 were located in Massachusetts and ranged from highly selective to less selective public and private colleges and universities. Five highly selective public and private universities outside of Massachusetts (popular choices among the students attending the two school systems I studied) were also included in the survey. I asked them about the kinds of mathematics program they would recommend for secondary students, whether or not taking calculus in high school is an important pre-requisite for admission to their school, and whether or not calculus enabled students to be more successful in their college programs.

The Views of College Admissions Officers

Before examining the variations among districts in their policies affecting course placement in mathematics, it is useful to review briefly the findings from the interviews with college admissions officers regarding the role of calculus in the high school curriculum. Most of the respondents could not answer the questions with precise data, so the information presented here is somewhat impressionistic. Nearly all of the admissions officers said that taking calculus "strengthened the application" to his or her college or university. They stressed, however, that this was only one of many factors that were taken into account in the admissions decisions at their schools. The fate of the applicant rarely turned on one course. However, at the most selective colleges, the question was virtually moot since the great majority of enrollees had had calculus in high school. Exceptions were made for those students who were economically disadvantaged, were exceptionally talented in other areas, or who attended a high school where calculus was not offered.

Admissions officers at all of the schools said that secondary school calculus was strongly recommended for those who wanted to go into engineering, mathematics, or a science major. It was less important for those in other fields except perhaps for students who were planning to major in a highly quantitative social science or in business. At highly selective engineering schools, the admissions officers claimed that high school calculus was the norm and students without it would have difficulty making it through the freshman curriculum.

According to the admissions officers, business and management programs definitely preferred students with a strong quantitative background, which meant at least four years of high school mathematics through trigonometry and precalculus. Students who had had calculus in high school were said to be somewhat advantaged in handling the quantitative requirements of business programs. Many if not most of these programs required calculus in college, and since the failure/withdraw rates were so high in that course, those who had had it in high school were more likely to complete the course successfully (Burton, 1989; D'Augustine, 1989).

This information from admissions people, limited as it is, does indicate that calculus is both an important "signal" to admissions officials at highly selective schools that the applicant is a "fast track" student as well as an objective indicator to admissions officers at all schools that a student aiming for a major in a quantitatively-oriented program will be more likely to succeed in that curriculum than his or her peer who did not take calculus. Since admission to the calculus track occurs at the end of sixth or seventh grade, it follows that students would be wise at that age to know what kind of college they wish to attend and what major and career they wish to pursue. This, of course, is not a reasonable expectation since twelve and thirteen year-olds do not have a firm idea of their probable colleges, majors, and careers. The current U.S. system of tracking in mathematics, however, presupposes such knowledge and closes doors to those who fail to be placed on the accelerated track.

Variations By District in Enrollment in Accelerated Mathematics

The variations among the 26 school districts in the percentages of students enrolled in eighth grade algebra and in calculus courses were striking. Statewide, a 1984 transcript study showed that about 15 percent of students were in the algebra course; a 1988 study using student self-reports put the proportion at 23 percent (Massachusetts Department of Education, 1985, 1988). In the present study, four of the 26 districts had fewer than 15 percent on this fast track (with a low of 13 percent in one city), nine had between 15 and 23 percent in this curriculum (near the state average), and 13 had more than 24 percent (Table 1). Three in this group had between 40 and 50 percent of their eighth graders in algebra.

Calculus enrollments varied dramatically as well. In the large urban

district included in the sample, calculus was not offered at most of the high schools in the city. The formal course was available to students at the three selective examination high schools and at a handful of the district's 13 district high schools. In all of the other 25 districts, however, calculus was offered, reflecting statewide data which show that 94 percent of Massachusetts students attend high schools where calculus is available (Massachusetts State Department of Education, 1985). Nationally, it should be noted, the figure is much lower--only about 30 percent of all high schools even offer calculus (although 57 percent of schools with more than 1400 students do so), so that only 55 percent of secondary students have the opportunity to be in a school building where calculus is part of the curriculum (Carroll, 1984; Weiss, 1987).

In the 26 districts studied, ten had student enrollments in the course that fell below the statewide average of 13.4 percent, nine had enrollments ranging between 13 and 19 percent, and seven had 20 percent or more of their students in calculus (Table 1). One district had 38 percent of its seniors in a full-year calculus course while another had 46 percent enrolled either in a full-year course or a one semester course. Overall, the percentage of students taking calculus varied from a low of 4 percent to a high of 46 percent among the 26 school districts. Several districts were in the process of changing their middle school placement policies and curriculum so that as many as 40 to 50 percent of their students in the future might take calculus or some other fifth year mathematics course (usually discrete math). Others were resisting such changes and even contemplating reducing their percentages in the top group.

Explanations for the Variations in Enrollment Patterns

There are two principal explanations for the variations in enrollment patterns which emerge from these data. First, the percentages of students enrolled in eighth grade algebra and in calculus varied according to the social class composition of the community. Those districts where parents had high levels of education were more likely to have higher proportions of students on the accelerated track. Second, the substantial variations in percentages of students on the fast track which existed even when class factors were taken into account could be partially explained by the educational philosophy of the districts' math chairs and coordinators (or, in some instances, principals). This philosophy concerned the importance of calculus in the high school curriculum, appropriate selection criteria for ability groups, and the role of parent and student preference in influencing course assignment.

The finding that larger proportions of students were enrolled in accelerated mathematics courses in communities with a high average parental educational level is not surprising. Much of the tracking literature has documented the relationship between students' social class backgrounds and their placement in curriculum tracks and ability groups. Results from the

Table 1. Distribution of School District Enrollments in Eighth Grade Algebra and Calculus by District Parental Education Level

District Parental Education Index	District Percentage of Eighth Graders Enrolled in Algebra			District Percentage of Seniors Enrolled in Calculus		
	High (>23%)	Medium (15-23%)	Low (<15%)	High (>20%)	Medium (13-19%)	Low (<13%)
High	8	1	1	5	4	1
Medium	4	3		2*	4	1
Low	1	5	3		1	8
Total	13	9	4	7	9	10
	Tau-b statistic=0.519, p=<0.002			Tau-b statistic=0.628, p=<0.001		

*one semester course

national High School and Beyond survey have shown that while 11 percent of students who rank high in socioeconomic status (SES) take calculus, only 4 percent of middle SES students and 1.5 percent of low SES students do so (Peng, 1984). A study of 3000 randomly selected transcripts of 1984 twelfth graders in Massachusetts, found that 24 percent of the students whose fathers have at least a college degree take calculus compared with only eight percent of the students whose fathers have not received education beyond the high school level (Mass. State Department of Education, 1986). Similarly, this same study as well as others have found that students from homes with better educated parents are more likely to be placed in eighth grade algebra (Kifer, 1986, 1989; Becker, 1990).

The relationship between student enrollments in the accelerated mathematics sequence and the average level of parent education in each of the 26 districts studied here was apparent from correlational and crosstabular data. (Tables 1 and 2) Parental education levels, which ranged on a scale from 2 to 8 points, were obtained for each school district from a study conducted by the State Department of Education and were coded as either "high," "medium," or "low" (Massachusetts State Department of Education, 1988).(2) Those labeled "high" are generally regarded as upper middle class districts, those categorized as "medium" are largely middle class communities, and those classified as "low" are districts whose students come mainly from poor and working class families. Districts were also categorized as either "high," "medium," or "low" in the proportion of students enrolled in algebra in the eighth grade and calculus in the twelfth grade. Those scoring in the range of the statwide mean in algebra (15 to 23 percent of the eighth graders) were classified as "medium," while districts scoring above and below that range were labeled as "high" and "low" respectively. With regard to calculus, districts whose enrollment percentages fell below the statewide mean of 13 percent were categorized as low, those falling at or just above the statewide mean (13-19 percent) were classified as "medium," while those with 20 percent or more of their senior classes enrolled in calculus were labeled "high" on that measure.

As the data in Tables 1 and 2 indicate, the relationship between the social class status of the school district, as measured by parental education levels, and course enrollments was quite pronounced. The zero-order correlation between parental education level and enrollment in eighth grade algebra was .40 ($p<.05$). Eight of the ten districts ranked high in parental education had a high percentage of students in eighth grade algebra compared with four of the seven districts ranking in the mid-range in parental education and only one of the nine districts with lower parental education levels. Of the four communities with a lower-than-average percentage of students in eighth grade algebra, three were poor and working class cities and towns.

The same relationship appeared when calculus enrollments were examined. The zero-order correlation between district parental education levels and enrollments in calculus was .46 ($p<.01$). Half of the upper middle class

Table 2. Zero-Order Correlations Among District-Level Variables

	Parental Education Index	Percentage in 8th Grade Algebra	Percentage in Calculus	Encouragement of Accelerated Mathematics
Parental Education Index		.40*	.46**	.21
Percentage in 8th Grade Algebra			.69**	.21
Percentage in Calculus				.49**

*significant at the .05 level
**significant at the .01 level

districts had more than 20 percent of their seniors enrolled in calculus compared with only two of the seven middle class districts and none of the poor and working class communities. Of the ten districts with below-average calculus enrollments, all but two were from blue collar cities and towns.

While the social class backgrounds of the students explained much of the variation among districts in accelerated mathematics enrollments in eighth and twelfth grades, school-level policies helped account for some of the difference as well. In particular, data from the administrator interviews indicated that several factors promote enrollments in this track. Administrators who believed that a high proportion of students would benefit from calculus (or another fifth year math course) tended to implement middle school tracking configurations that encouraged a high proportion of students to be in the accelerated curriculum. Those who thought that most students were better off beginning the study of calculus in college were likely to restrict enrollments in the eighth grade algebra course. These administrators usually opposed the creation of a non-AP calculus course (in addition to the AP course) for twelfth graders, a course whose existence substantially boosts calculus enrollments.

The range of views on this issue that emerged in this study reflects the lack of consensus among mathematics educators nationally. In 1986, the National Council of Teachers of Mathematics (NCTM), the professional assocation of elementary and secondary teachers, and the Mathematics Association of America (MAA), which represents the position of college and university mathematics teachers, sent a letter to secondary teachers recommending that high school calculus only be taught as an Advanced Placement college-level course where students follow the prescribed AP curriculum and test out of the introductory college calculus course. The letter argued that students taking a non-AP calculus class (about 80 to 85 percent of calculus enrollees) were then repeating introductory calculus in college, causing them to avoid serious study in the high school course and to become dangerously overconfident in their college calculus course (Steen and Dossey, 1986; Steen, 1987). Many of the administrators I interviewed had seen this letter but did not agree with the recommendations. The Curriculum and Evaluation Standards for School Mathematics put out by the NCTM in 1989 do not recommend the formal study of calculus in high school but do suggest that students be introduced informally to certain calculus concepts in other mathematics courses (NCTM, 1989).

Besides differing over the importance of calculus in the high school curriculum, administrators had very different attitudes about placement criteria for ability grouping. Some districts had an elaborate set of criteria, including scores on both local and national tests as well as grades and teacher recommendations. Some relied heavily on the standardized test scores and had very high cutoff points for admission to the accelerated group. For example, in some of the wealthier districts, the students admitted to the eighth grade algebra course scored in the top one or two percent nationally in mathematics, a result of district policies which

selected out only the very best in that particular community, even though the average score among all children in that community was extremely high. Other towns had far less restrictive test score criteria for admission to the fast track (e.g. a student could score in the top 25 percent nationally), and some relied almost exclusively on teacher recommendations rather than test scores.

The districts also differed on the degree to which they allowed parents and students to override a teacher's recommendation for course placement. Some systems had well developed policies that forbade or discouraged overrides whereas others were relatively open to requests that a student be placed in a higher ability group. Administrators in some districts were openly hostile to parental intervention while in others it was welcomed. In addition, there was some district variation in the degree to which "late blooming" and transfer students at the high school level were encouraged to double up on mathematics courses in their sophomore or junior years in an effort to reach calculus. Some administrators actively encouraged students to do so, loaning them books to study over the summer and assisting in course scheduling.

To quantify the relationship between these organizational variables and student enrollment patterns, districts were classified as being either "encouraging," "mixed," or "discouraging" in their placement policies in accelerated math in the middle school and secondary levels. A "District Encouragement of Accelerated Mathematics Scale" was created, an additive scale from 0-5 points, made up of a ranking of the selectivity of the district in admission to the accelerated curriculum (including the degree of reliance on standardized test scores) (0-2 points); how important the teaching of calculus in high school was in the minds of administrators (0-2 points); and how flexible and encouraging the system was with regard to parental overrides and the doubling up in secondary mathematics courses (0-1 points).(3) This variable was crosstabulated with the proportion of students enrolled in calculus, controlling for the level of parental education in the district (Table 3).

Overall, 7 of the 26 systems (27 percent) were classified as "discouraging" students in the pursuit of accelerated math while nearly a third were seen as "encouraging" students in that direction, with the rest of the systems falling somewhere in between. There was a small tendency for systems with high parental education index scores to be ranked as "encouraging" and for districts with low parental education to be characterized as "discouraging" (Table 2). Only one of the districts which scored low on the parental education index was ranked as encouraging the study of advanced mathematics leading to calculus while five of the ten districts with high levels of parental education received such a ranking. These districts were somewhat more likely to have inflexible and test-score driven tracking policies and to downplay the importance of calculus, and affluent districts were a little more likely to stress calculus and to have less rigid assignment procedures. But the diversity in policies and

Table 3. Distribution of District Enrollments in Calculus by District Parental Education Level and District Encouragement of Accelerated Mathematics

District Parental Education Level	District Encouragement of Accelerated Mathematics								
	Encouraging			Mixed			Discouraging		
	District Percentage of Seniors Enrolled in Calculus								
	High	Medium	Low	High	Medium	Low	High	Medium	Low
High	4	1		1		1		3	
Medium	1	1		1	2	1		1	
Low			1		1	4			3
Total	5	2	1	2	3	6		4	3

philosophy among districts similar in social class was more interesting from a policy perspective than the similarities among them. Indeed, three of the most affluent districts in the study had policies that discouraged assignment to the accelerated sequence of mathematics courses.

As expected, the percentage of students enrolled in calculus in a school district was related to district scores on the "Encouragement of Accelerated Mathematics Scale." The zero-order correlation between the Encouragement Scale and the calculus enrollment variable was .49 ($p<.01$) (Table 2). Of the seven districts with high enrollments in calculus (20 percent or more of the senior class), five were classified as "encouraging" and two were characterized as "mixed." No district with a "discouraging" climate had high calculus enrollments. Of the ten systems with low enrollments in calculus, three were "discouraging," six were "mixed" and only one, (located in a working class community), was "encouraging" (Table 3).

The data in Table 3 show the joint effects of district parental education level and school policy on calculus enrollments. The parental education effects reflect the fact that students from more affluent homes were much more likely to pursue calculus and to attend schools in districts whose policies encouraged the study of accelerated mathematics. For example, of the five systems that were high both in calculus enrollments and in "encouragement" for accelerated mathematics, four were in districts ranked high in parental education. At the other extreme, of the three cities that ranked low both in calculus enrollments and in "encouragement," all had low levels of parent education. However, there was still considerable dispersion on the enrollment and "encouragement" variables among communities of similar social class, a phenomenon which illustrates the importance of local school-based policies and processes. Three of the ten systems classified as high in parent education, for example, were "discouraging" contexts for the study of accelerated mathematics and had calculus enrollments that were only in the moderate range.

The comments of administrators from one district to the next show how idiosyncratic school placement philosphy and practice can be. The following is a sampling of the diversity of opinion among the mathematics department chairs and coordinators who were interviewed.

On selection into groups:

> We wanted to segregate the top group students [in fourth grade] as early as we could ... and in sixth grade they are grouped as homogeneously in math as we can get them ... it is efficient that way ... In high school we make the push to make kids realize their own capabilities and not think they can do more than they can.
>
> It is better to have more kids in the middle grade

accelerated math because once they are cut out, it is extremely hard to get back in ... Many are late bloomers ... They are bright but are not ready at that time but are ready two years later and you have cast a lifetime sentence on them. Some baseball players make the major leagues who never made little league ... It is easier to have homogeneous grouping and restrict the numbers in eighth grade algebra but the harm that that does to the other 20-30 percent is unforgiveable philosophically.

It is better to make a mistake and err in the direction of holding a kid back.

We are not squeezing kids out too early and we encourage kids to double up ... I could have higher AP scores and higher Math II Achievement Test scores if I took only the top 10-15 percent in Grade 8 algebra but that would wipe out a whole group of kids.

Just because a kid has a high I.Q. doesn't mean he's capable of doing algebra in the eighth grade. He may not have the neural connections ... you can expect too much.

I believe in 'let them try it' ... They can always drop back. Always give the kid the benefit of the doubt. Once you go down a notch, it is hard to get back up.

I follow the 8th-9th grade placement criteria <u>rigidly</u> (except for ESL kids) even when I know a kid can make it [who doesn't meet the formal criteria].

We <u>like</u> to overpopulate the seventh grade pre-algebra so the students will have an opportunity. There used to be only 10 percent taking algebra in grade 8 and we have intentionally lifted the percentage to 25-30 percent. We made algebra in the eighth grade an <u>elite</u> course. We grossly underestimated the abilities of a lot of our kids. We have to be flexible if we want more kids involved in math.

Some people say it is a working class community and we shouldn't have too many people in accelerated math.

On the role of calculus in the high school curriculum:

Calculus is only for a few kids. Colleges want to discourage calculus in high school unless kids take AP and place out [of the introductory calculus course in college]. Kids who repeat calculus in college don't do well ... It is a myth at this high school that Johnny won't get into

a prestigious school if he is not in honors math.

Students are much better off with calculus in high school. They are lost without it in college calculus classes because they are in there with kids who've had AP calculus who are taking it once again. If you have no idea, you're gone and you're gone forever ... [The college professor groups who discourage high schools from offering calculus] are completely out of touch.

Who cares if kids don't take calculus in high school ... it doesn't close any doors ... They get along fine and can get into good colleges.

It is an open question whether calculus is needed in high school. It is highly overrated as a necessity in high school. The general public wants calculus and sees discrete math as a frill ... Yet we need to prepare kids for calculus because it opens significant doors to science and technology. So we need to offer it. We need AP calculus for those who are motivated and capable ... Kids appreciate the non-AP calculus too. It makes their transition to college easy. They say 'math is easy this year' and acquire a confidence that will pay off. I have little patience with college professors' arguments [against teaching non-AP calculus in high school]. It is the wrong approach to tell high schools to teach less math. We should teach <u>more</u>, not less.

I'd like to see only 8-10 kids take calculus but our kids need it for college admissions. I <u>know</u> it is important for college admissions. Students [who've had calculus] will get into Harvard more easily than those who don't have it. We are caught in the college admissions process.

If you don't take calculus in high school, you take it in college and you don't need it for admission to top universities.

There is no question that high school calculus helps <u>immensely</u> with college calculus. High school teachers teach it <u>better</u> ... We test only what we have gone over in class, unlike colleges.

Students repeat calculus in college and say it was good to have had it. They remember struggling in calculus and laugh now to see others in college <u>really</u> struggling in calculus. They are using their high school notes. The pace in college is much faster than high school and concepts become clearer the second time around.

Our students want non-AP calculus but the experts have told

us not to offer it.

> I favor having kids get into calculus. We should find ways to help them get around roadblocks ... Teachers don't always agree but they know my philosophy and do it ... I'm more important than the principal.

The opinions of these mathematics chairs and coordinators were reflected in school policy. Department chairs in these districts hold their positions indefinitely and are usually appointed by the school administration. Thus these chairs, who remain in their jobs for many years, are in a position to put their own stamp on course offerings, ability grouping configurations, placement criteria, and rules about parental intervention. Some of the variation among school districts in curriculum and grouping policies, therefore, can be traced to the particular attitudes of the incumbent chair or coordinator.

Other Organizational Factors Affecting Ability Group Assignment

Other organizational factors influence ability group assignment as well, factors which help explain the vagaries in course placement among schools and among districts. School size was one of these variables. In one K-8 system, 8th grade algebra was offered in only some of the larger elementary schools; another K-8 system varied in the number of ability groups in eighth grade according to school size. A number of administrators commented that as student enrollments have fallen over the last two decades, the number of ability groups have fallen as well. There are simply not enough students in a grade to fill up the five or so levels that used to exist. Perhaps this accounts for the overall drop in grouping in secondary schools that occurred during the 1970s and early 1980s (Ekstrom et al., 1988).

While systematic data on scheduling issues were not collected, it became apparent during the interviews that the existence of vacancies often affected students' probabilities of being placed in an accelerated mathematics class. Administrators in five districts said that in order to fill accelerated classes, they sometimes placed middle grades students in those classes whose test scores and grades fell below the accelerated cutoff points. In one of these systems, students' probability of being placed in accelerated mathematics was greatly increased when the middle school adopted a cluster organization pattern with one accelerated math course attached to each cluster of 100 students. Prior to the implementation of the cluster system, each grade had only one accelerated section, enrolling a small group of high achievers. The reverse was the case in two other districts where administrators cited specific instances of qualified students being moved down to a lower group because the accelerated class was too large. One system had a strict quota system, allowing each elementary school to recommend a specific number of students for the accelerated mathematics program, ignoring the ability range of the students that year in each

school.

In one city school system in the sample, access to eighth grade algebra and to calculus was generally available only to those who were selected by examination at the end of sixth or eighth grade to attend one of the city's three select academic high schools. Otherwise qualified students who did poorly on the test could not be admitted and thus could not take calculus in high school unless they took it a community college or unless they happened to be assigned to one of the few other high schools in the system that offered calculus. Qualified students who moved into the system after eighth grade were ineligible to attend one of the select high schools and had to make do with the courses that they found at their assigned high school. Students going into the select high schools from the public elementary and middle schools were usually drawn from a special enriched "pullout program" that began in the fourth grade. Placement in this program depended on a standardized test score taken in the second grade. Administrators in the district acknowledged that math course assignment in the non-select secondary schools was haphazard, often made without test score data or prior performance information on students and heavily influenced by scheduling considerations (see Mass. Advocacy Center, 1990, for a detailed analysis of tracking practices in this system).

The official practice of linking mathematics course placements to placement in other subjects has been abandoned in the great majority of these school districts, but in a few districts the practice remains. In one city system serving large numbers of limited-English-speaking students, most middle schools grouped students according to their reading scores for all of their core academic subjects. A pupil who was strong in mathematics but poor in reading in this system was generally placed in a low mathematics group. In another system, the middle school English placement was determined by the math placement decision. One system grouped students in all academic subjects according to their mathematics placement. When five students were removed from an accelerated mathematics class because it was overcrowded, these five students were moved down a level in all of their academic courses.

School systems such as those discussed above that have grouping practices creating extensive misclassification of students tend to be those that have poor and working class student bodies. In more affluent school districts, administrators tend to be more informed about national trends and school reforms, and activist parents are more likely to challenge such inflexible grouping policies.

The Case Studies

The variations in philosophy and policy among administrators from district to district are highlighted in the two case studies of contiguous school districts serving students of similar social class backgrounds. Two schools were selected for study. In Community A, one of the two junior high

schools (grades 7 and 8) was studied and in Community B, the town's one middle school (grades 6-8) was included in the research.

These two districts had much in common. Students came largely from middle to upper-middle class backgrounds; the schools were well-run and commanded substantial parent support and pride; the mathematics teachers were experienced and well-qualified; the middle grades had been reorganized in a cluster system where students shared a group of teachers for core academic subjects; ability grouping in the middle grades had been eliminated in some subjects, remaining only in mathematics in Community A and in English and mathematics in Community B. Further, the administrators in both systems (principals, curriculum coordinators and department chairs) were well-informed about new developments in their field and implemented meaningful in-service training programs for their teachers. Test scores in both systems were relatively high.(4)

There were significant variations, however, between the two schools in their ability grouping philosophy and policies in mathematics which led to differences in enrollments in the accelerated sequence of courses. The prevailing view in Community A was that accelerated mathematics, which began with pre-algebra in the seventh grade, was for students with "exceptional ability." According to national criteria, the average student in this system was already somewhat exceptional since the average mathematics score among sixth and eighth graders on a standardized test placed them in the 95th percentile and above on both computations and concepts. Despite this, in order to be recommended for placement in accelerated mathematics, students at the end of sixth grade had to score high on two out of three criteria--a score in the top 15 percent among students in that town on a national standardized test (which equalled the top 1-2 percent nationally), a score above the cutoff on a locally-designed math test, and their sixth grade teacher's recommendation.

Parents in this system could override the recommended placement, and many chose to do so, but they were usually told that "overrides don't make it" in accelerated math. Twenty-five percent of the seventh graders, about one fourth of them "overrides," were in the accelerated group. By eighth grade, only 20 percent remained in the accelerated program, a smaller percentage than one estimate of the statewide average. And by senior year in high school, only 12 percent enrolled in calculus, again a smaller percentage than the statewide average. A course in discrete mathematics was available also as a fifth year option but no non-AP calculus was offered. Administrators and the sixth and seventh grade teachers who were interviewed tended to downplay the long-range implications of the math placement for students' future educational and employment opportunities and did not feel that calculus was particularly important for college admission or for success in college. Some noted that parents' anxieties about the math placement were unjustified. ("Children can <u>still</u> be doctors if they are in Regular math. The ones who don't take calculus in high school can take it in college.)

In Community B, a less elitist philosophy about mathematics achievement guided placement and curriculum decisions. Placement in the accelerated sequence was based almost entirely on teacher recommendations. There were no test score cutoff points for admission to the seventh grade pre-algebra group. During the year the study was conducted (1988-89), approximately 30 percent of the seventh graders were in the pre-algebra group and 27-30 percent of the eighth graders were taking algebra. Moreover, the system was in the process of adopting a new policy that would place more than 40 percent of all seventh and eighth graders on the accelerated track with the hope that almost all of them would persist through calculus. Already, 23-24 percent of the seniors were enrolled in either of the two AP calculus course options or a year-long non-AP calculus, twice the number enrolled in Community A. Significant numbers of students (15-20 a year) doubled up on mathematics courses in a single year to move up a level.

The Mathemathics Chair in Community B believed strongly that calculus was important both for college admissions and for subsequent success in college mathematics. ("Calculus is not for everyone but many more people should take it.") Teachers supported the notion of boosting more students in mathematics and, in general, believed that parents were not to be discouraged from overriding a teacher's recommendation for course placement. Teachers at all of the grade levels interviewed (5th through 8th) were willing to carrry an overload in the accelerated classes in order to give more students the opportunity to be placed there. The attitude of the Mathematics Chair typified the district's mistrust of early and rigid ability grouping:

> My experience in math has been like my experience in coaching soccer. When you cut a kid in sports, it's all over. It takes great courage to go out for that sport again. It is the same in math. If you are sorted out in math early, you've lost out right off the bat.

In the words of the mathematics education community, Community A has policies which serve to "filter" students out of advanced mathematics while Community B has procedures which "pump" them on to higher levels of the subject.(5) Thus the remarkably different approaches to student selection into accelerated mathematics of two adjacent communities serving similar student bodies result in quite different "yields" of students prepared to move on more easily to college mathematics.

A note of caution, however, should be introduced here. There are many ways in which secondary mathematics programs can be exemplary. For example, a school may be particularly good at recruiting and retaining strong teachers, or in teaching low achievers, or in retaining large numbers of average students in four years of mathematics, or in teaching the most advanced students (Driscoll, 1987). Community A was strong on several of these other dimensions. This study looked at only one dimension of a mathematics

program: its success in enouraging a relatively high proportion of students to pursue mathematics through calculus.

Conclusion

The findings from this study confirm the observations of Kifer (1987, 1989) that there are substantial variations in ability group assignment policies in middle school mathematics among school districts that lead to inequities and arbitrary elements in students' placement. The range of abilities which Kifer found among students enrolled in eighth grade algebra nationally can in part be explained by students' individual background characteristics, but can also be explained by the range in attitudes among school administrators about the importance of accelerated mathematics and the proper criteria for selecting students for that course sequence. Students who would be deemed fully qualified for accelerated math in one system could easily find themselves rejected for that same track in an adjacent school district. One principal of an inner-city middle school (who branded the early tracking policies of her school system as being "absolutely ludicrous") commented that by her criteria, virtually all of the children in neighboring affluent districts were qualified for placement in an accelerated program.

Mathematics tracking in the U.S. generally operates in a way that rewards only those students who are high achievers early in their school careers. Selection for accelerated mathematics usually occurs at the end of sixth grade (sometimes at the end of the fifth or seventh grades), long before students have a firm idea of their future educational and occupational plans. Students who are not accelerated in the middle grades are placed in "Regular" mathematics where they undergo a kind of "forced deceleration" in an arithmetic-driven curriculum that repeats much of what they learned in elementary school (Flanders, 1987; Usiskin, 1987, 1988). This experience contrasts sharply with that of students in many other industrialized countries where students in seventh and eighth grade are routinely exposed to algebra (McKnight, 1987). The early sorting of U.S. students into rigid ability groups reflects the view among U.S. teachers and parents that mathematics achievement depends more on innate ability than it does on effort (Stevenson et al., 1986; Stigler and Perry, 1988).

The evidence from this study of 26 public school districts in the Boston area shows that many of the systems, including some where students come from highly educated homes, adopt very restrictive placement practices in the middle grades which artificially restrict the flow of students into accelerated mathematics leading to twelfth grade calculus. As Kifer (1989) has pointed out, "we have tracked so rigorously by grade eight that we have, in fact, assured that participation in advanced mathematics is going to be small in our secondary schools."(p. 11) These practices substantially diminish the supply of students who are prepared to handle introductory college calculus, the "gateway" course to mathematics and science and a pre-requisite in more than half of all college majors. Not all public schools

do this, however. What is interesting is that almost a third of the districts studied were successful in "pumping" more than 20 percent of their students through calculus on the accelerated track while nearby districts consciously filtered students out of this course sequence.

Districts with high enrollments of students on the "fast track" tended to be those with high average parental levels of education. A community's elevated social class level, however, did not guarantee that a high proportion of students would be placed in the accelerated sequence. For that to occur, the district's mathematics administrators or principals usually had to have a strong commitment to flexible and non-restrictive placement criteria in the middle grades, an encouraging attitude toward parents and students who wanted to catch up to the accelerated sequence, and a belief that calculus in high school could benefit many students. The latter belief usually translated into offering a non-Advanced Placement Calculus course as well as the Advanced Placement courses.

It was also apparent from the data that other kinds of school and district-level policies affected students' chances of being exposed to the most rigorous mathematics that a school system offered. Scheduling considerations, especially the need to fill classes in the middle grades, played a role in student placement in many schools. School size at all grade levels influenced the number of ability groups and course offerings in mathematics. Pullout programs and select junior high and secondary schools were, by definition, space-limited, putting caps on enrollment regardless of the numbers of students qualified for such programs. And in some schools, students' math placement was still determined by their reading scores. Given the variations in philosophy and practice from district to district, it is no wonder that national surveys find such a range of achievement among students assigned to the same course. These findings corroborate the views of Sorensen (1987) and Garet and DeLany (1988) who argue that local policies create a "microstructure" of grouping within each school, and these school-level stratification systems play a significant role in students' opportunities to learn certain subject matter.

These organizational constraints on learning opportunities raise serious questions about social equity and the qualifications of our future workforce. From the standpoint of equity, this and other studies show that students whose parents are better educated are much more likely to be placed on the fast track in mathematics and to complete a high school calculus course (Kifer, 1986, 1987; Massachusetts State Department of Education, 1986; Useem, 1990a,b). This finding reflects the multitude of advantages such students bring with them to the educational process, including their parents' overt efforts to have them placed in accelerated groups, but also the fact that they are more likely to be in schools that offer accelerated courses and encourage a higher proportion of students to be placed in them.

The picture for females is somewhat mixed. They are slightly more likely than males to be placed in algebra in the eighth grade but by twelfth

grade, they are less likely than males to persist through calculus. Still, nearly 40 per cent of those taking the AP test in calculus in 1988 were female and about 46 per cent of all college undergraduate degrees in mathematics go to women (CEEB, 1988; National Research Council, 1989).

The opportunities for blacks and Hispanics to be placed in the accelerated track are especially bleak. According to the High School and Beyond transcript study, only two percent of non-Asian minorities were enrolled in calculus compared to six percent of whites and 15 percent of Asian-Americans (Peng, 1984). Data from the Advanced Placement examinations in calculus tell the same story: in 1988, of the 65,274 students taking either one of the two AP calculus exams, only 2.9 percent were black and only 1.4 percent were Puerto Rican or Mexican-American. Further, the average test score for these groups was below the passing mark of 3. In Massachusetts, the site of this study, a total of 28 black students in the entire state (20 of them from private schools) and 14 Puerto Ricans and Chicanos took the AP calculus exam. Of those who graduated from public schools, only six blacks and three Puerto Ricans and Chicanos in the entire state received a passing grade (CEEB, 1988). With so few in the advanced mathematics pipeline, it is not surprising that only four black-Americans earned doctorates in mathematics in the U.S. in 1988 (Chronicle of Higher Education, 1989).

Apart from the serious issue of equality of opportunity for students, the question of workforce quality must be considered as well. The consequence of assigning so few to a rigorous mathematics program in the middle grades and secondary schools means that the supply of highly trained students flowing into U.S. colleges and universities is exceedingly small. Very few are prepared to handle college-level mathematics with a degree of success. Indeed, as a recent report from the National Research Council notes, without the influx of international students to U.S. colleges and universities, the mathematics and scientific disciplines "would be in total disarray" (National Research Council, 1989, p. 26). A bevy of reports by national blue-ribbon commissions have warned that the lack of proficiency in mathematics among U.S. students at all levels is leading to an insufficiently trained workforce in a competitive global economy where "working smarter is more important than working harder" (National Research Council, 1989, p. 1; Dertouzos et al., 1989; U.S. Department of Labor, 1989).

Despite the crisis in mathematics training, however, colleges, universities and the professional associations of mathematics teachers and professors have sent mixed messages to middle and secondary schools about tracking policies and access to calculus in high school. The mathematics education community has largely ignored or sidestepped the issue of tracking (NCTM, 1989). The most prominent voices criticizing inflexible and early sorting of students have come from outside of the mathematics community (e.g. Carnegie Council on Adolescent Development, 1989; Mitchell, 1989; Massachusetts Advocacy Center, 1990) although there are a few notable

exceptions (McKnight, 1987; Usiskin, 1987, 1988). Moreover, the official policy of the professional groups representing secondary and college-level mathematics teachers discourages the offering of calculus in high school unless it is taught as an Advanced Placement course. Mathematics professors have not reached a consensus among themselves about whether or not students should begin an accelerated program in the middle grades and, if so, what sort of twelfth grade course would be approporiate. The division of opinion among high school mathematics teachers and administrators reflects the divisions found among their counterparts in academe. This lack of consensus allows school administrators, who determine course offerings and placement practices, to follow their personal philosophies in setting policy.

It is these variations in administrative policy from school to school that help explain why there are such wide differences in prior achievement among students assigned to the fast track in mathematics in the U.S. With this in mind, researchers should direct their attention to the range of organizational practices among schools as they seek to explain student achievement patterns. In addition, researchers need to make fine distinctions among specific coursework patterns within the amorphous academic track if they are to ferret out the true effects of tracking on achievement. For policymakers, the results of this study suggest that if the proportion of students trained in advanced mathematics is to increase and to include students from a wider range of social class and racial backgrounds, then middle and high school tracking and curricular policies must undergo substantial alteration. The exclusive and elitist character of course assignment policies in many school districts virtually guarantees that the pool of mathematically capable students leaving high school will continue to be both unrepresentative in composition and insufficient in size.

FOOTNOTES

1. According to data collected by the Massachusetts Department of Education, the average level of parental education in the two communities is nearly identical. On a Parental Education Index ranging from 2-8, Community A has an average of 6.67 and Community B's average is 6.64. Their scores on the percentage of students receiving free or reduced-price lunches are nearly the same as well.

2. Parental Education Index scores for these communities ranged from 3.79 to 7.20 with a mean of 5.64. The range of possible values for the scale was 2-8 points. All but two of the districts had index scores between 4.0 and 7.0. Districts coded "high" on this variable had scores of 6.1 or more,

those classified as "medium" had scores between 5.1 and 6.0, and those coded "low" had scores below 5.0. A low score meant that at least one parent, on average, did not have more than a high school education. A high score meant that at least one parent had graduated from college or that both parents had at least some years of postsecondary schooling.

3. On the "District Encouragement of Accelerated Mathematics Scale," High=4-5 points; Medium=2-3 points; Low=0-1 points.

4. The 1988 SAT mathematics score for Communities A and B were 531 and 527 respectively. In Community A, 84 percent of the graduating seniors took the test compared with more than 90 percent in Community B. More than 90 percent of the students in both communities received passing scores on the Massachusetts Basic Skills Tests given in 1987-88 and 1988-89. Both districts scored relatively high on the Massachusetts Educational Assessment Tests given at three grade levels in 1986 and 1988.

5. The notion of mathematics being either a "pump" or a "filter" was apparently first used by Lucy Sells. Robert White, president of the National Academy of Engineering, has also written about the importance of calculus becoming a pump rather than a filter in the mathematics pipeline. The metaphor is widely cited among mathematics educators. See, for example, Steen (1987) and National Research Council (1989).

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